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Jeffrey P. Sutton, M.D., Ph.D.

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General Hospital Corporation
Fruit Street
Boston, MA 02114

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Office of Naval Research - Prog Officer: Dr. Joel L. Davis ONR 342CN
Ballston Centre Tower One
800 North Quincy Street
Arlington, VA 22217-5660

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14. ABSTRACT

The Network of Networks (NoN) model, which is a neurobiologically motivated smart algorithm co-developed by the PI, is being applied for rapid and accurate image processing of forward and side scan sonar images in turbid environments. The model is also being used as a platform for rapid distributed communications for autonomous vehicles. Both of these applications build upon unique features of the NoN for reconfigurable computing across multiple scales of organization.

15. SUBJECT TERMS

neural networks, sonar, autonomous vehicles, image enhancement, communications

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a. REPORT	b. ABSTRACT	c. THIS PAGE			Jeffrey P. Sutton
UU			SAR		19b. TELEPONE NUMBER (Include area code) (617) 726-4350

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ANNUAL TECHNICAL REPORT

12 April 2000

ONR N00014-99-1-0884

10 April 1999 - 09 April 2000

Program Officer: Dr. Joel L. Davis, ONR 342CN

Project Title: Reconfigurable Network of Networks for Multi-Scale Computing

Recipient Institution: Massachusetts General Hospital

Principal Investigator: Dr. Jeffrey P. Sutton

Objective:

The aim of this project is to extend and apply the Network of Networks (NoN) model to (a) rapid underwater image processing in turbid environments and (b) coherent real-time signal processing for intelligent autonomy.

Approach:

The NoN model is a neurobiologically motivated and reconfigurable computing architecture for multi-scale computing. It was co-developed, and has been applied, by the principal investigator for underwater mine deblurring. In this project, computer simulations, neurobiological information and engineering constraints are being used to apply the NoN for real time underwater image enhancement and classification. The dynamic properties among neural networks comprising the NoN are also being applied to examine communications among autonomous entities. Biologically inspired signal processing is being used to investigate how a network of autonomous vehicles may reconfigure and rapidly adapt to changing conditions without the need for a master controller.

Progress:

1. A user friendly PC graphical interface has been developed for a NoN motivated algorithm, known as the Sutton-Guan (SG) algorithm. The interface allows sonar images, such as those acquired by collaborators – G. Dobeck (Code R12, NSWC CSS, Panama City FL), P. Pitt (Applied Research Lab, U Texas at Austin and Lake Travis sonar test site) and L. Guan (Electrical Engineering, U Sydney, Australia) – to be enhanced for target specification. The enhancement is particularly effective in the presence of inhomogeneous noise, and a user option gives a graphical depiction of the noise. This signature may be important in determining the context of image deblurring.

2. The SG algorithm has been extended to two new NoN motivated algorithms – the segmentation-variance (SV) algorithm and the dynamic segmentation and classification (DSC) algorithm. These algorithms were developed with Sutton's AASERT student at MIT (ONR N00014-98-1-0511). Classification remains a difficult problem for sonar images and these two new algorithms hold promise for semi-automated to automated recognition with minimal training. The performance of the algorithms

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was tested by classifying structures on brain MRI images (paper submitted). It is planned to test the algorithms using large aperture forward scan sonar images.

3. The NoN model is being adapted to test communications among multiple networks for dynamic and optimal reconfiguration at a global network level. Each network within the global network has signal recognition capabilities, which are similar to the radar deinterleaving properties of the networks developed by J. Anderson at QCD Associates, Rhode Island. The hypothesis is that near instantaneous communications among different networks, occurring prior to signal recognition within local networks, will enhance the performance of the overall / global network (of networks). This hypothesis is motivated by neocortical mechanisms, and may have applications to communications among a network of autonomous vehicles (research sponsored by UCAV ONR Program Officer: Dr. Allen Moshfegh, ONR 351).

4. Several new working groups and contacts have been established to foster the research on autonomous vehicles. There is collaboration between the principal investigator and the following investigators: at MIT – Eric Feron; at Scientific Systems Co. Inc. – R. Mahra, B. Raavichandran, I. Jamieson; at Draper Labs – R. Sincavage; at Harvard – A. Dempster, L. Ho.

Significance:

The NoN model and its associated, biologically motivated, algorithms have the capacity for rapid and accurate image processing of forward and side scan sonar images in turbid environments. The model also provides a platform for reconfigurable networks across multiple scales of organization. This property may have applications for rapid communications in networks of autonomous vehicles.

Presentations:

April 1999	SPIE Conference on Detection and Remediation Technologies for Mines and Minelike Targets
August 1999	ONR Autonomous Agent and UCAV Summer Review
October 1999	MIT, Mechanical Engineering
January 2000	ONR Autonomous Agent and UCAV Winter Review
February 2000	MIT Center for Intelligent Control Systems
February 2000	Keynote, Joint Conference on Information Sciences
March 2000	Harvard – MIT Division of Health Sciences and Technology
March 2000	MGH Center for Innovative Minimal Invasive Therapies
April 2000	NewcoGen Group

Publications:

Sutton JP, Sha DD, Perry S, Guan L. Enhancing mine signatures in sonar images using nested neural networks. *Proceedings of the International Society for Optical Engineering, Vol. 3710. 1999:570-577.*

Sha DD, Sutton JP. Towards automated enhancement, segmentation and classification of digital brain images using Networks of Networks. *Information Sciences.* In press.